



Mitigating Exploits, Rootkits and Advanced Persistent Threats

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Intel Corporation

Hot Chips Tutorial

Agenda

Problem
Better Protection
Solid Foundations
Usages
Minimizing TCB
Summary

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Increasingly Sophisticated Attacks

Operation Aurora: "Google announced an attack targeting it and what is believed to be more than 30 other companies"



CNET January 12, 2010

Stuxnet: "...a novel way to use computers to sabotage an enemy's lifeline infrastructure suggests a powerful new kind of weapon is moving within reach of weak states, militant groups and criminals..."



REUTERS

Reuters Nov 30, 2010

The Heartbleed Vulnerability: What It Is and How It Affects You: "...Heartbleed is not a virus, but rather a mistake written into OpenSSL" April 2014



Banking Malware (SpyEye) Monitors Victims by Hijacking Webcams and Microphones
May 2012, *PCWorld*

PCWorld

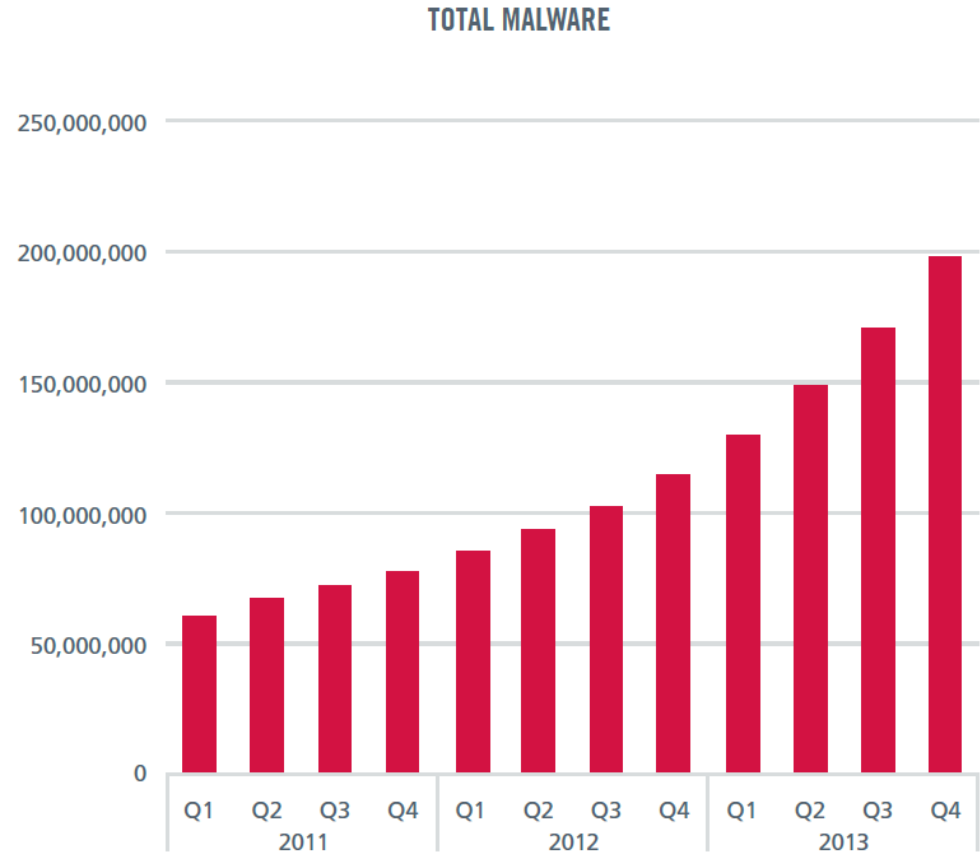
Meet 'Flame,' The Massive Spy Malware

"...designed primarily to spy on the users of infected computers and steal data from them, including documents, recorded conversations and keystrokes." May 2012, *Wired*

WIRED

Malware Signatures More & More...

- Malware samples continue sharp rise
- Polymorphic viruses
- Methods of packing, redistributing existing malware
- Looking for known malware misses 0-days and targeted attacks



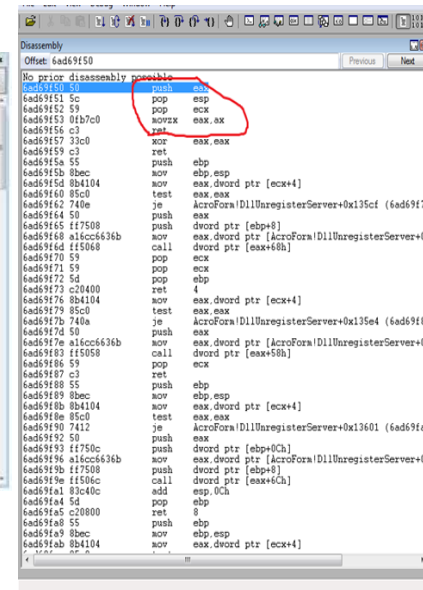
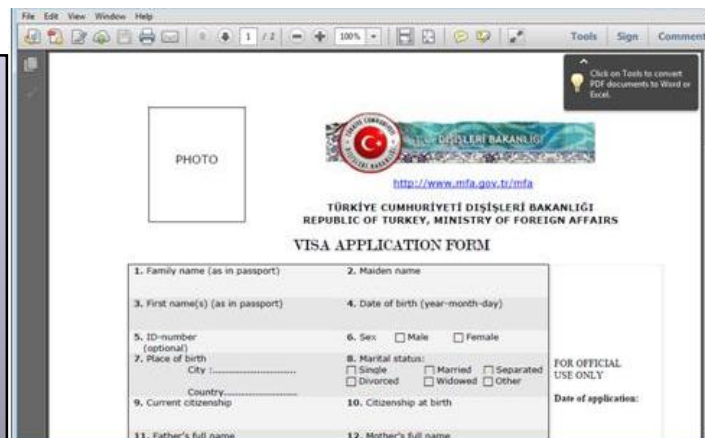
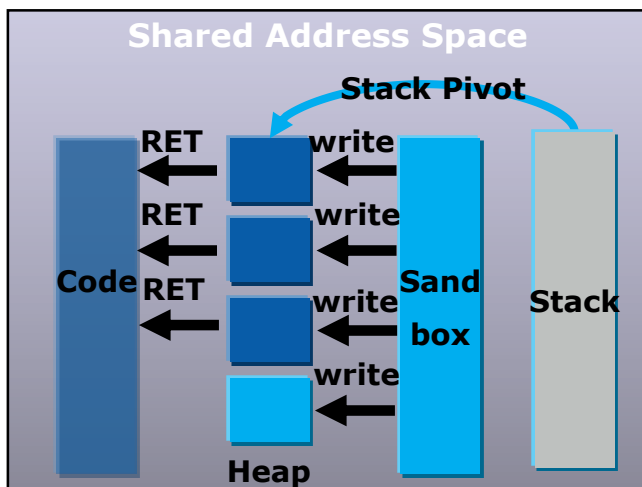
Source: McAfee Labs, 2014.

0-Day: Vulnerability, Armed, Exploited

Sample: APSA13-02 Exploit Analysis

Malicious File											
	Acro32	Trigger 1 st Vul	StackPivoting	D.T	2 Threads	IPC	StackPivoting	L2P.T	L2P.T	L2P.T	Acro32
Sandboxed Reader	Open PDF file	Heap Overflow	Run ROP Stackpivoting	Create and Load D.T Library	1: Show Error 2: Create L2P.T	IPC to trigger 2nd vul, then quit					New Process shows Visaform Turkey.pdf
Normal Reader					Heap Overflow	Run ROP via Stackpivoting	Load L2P.T	Create Langbar.dll And load it	Create Visaform Turkey.pdf	Create new sandboxed process to open new pdf	

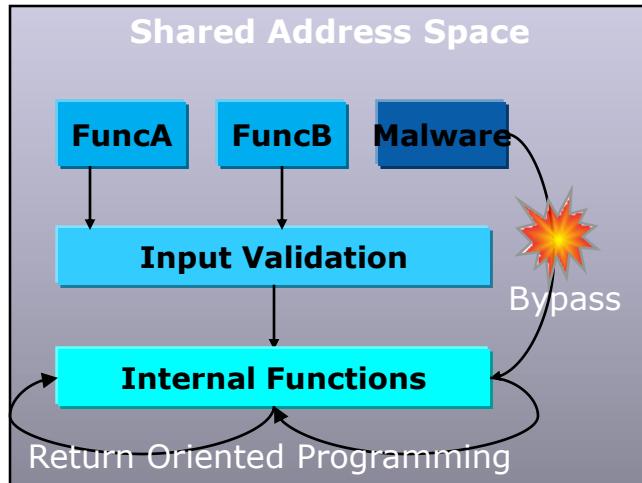
Stack Pivot



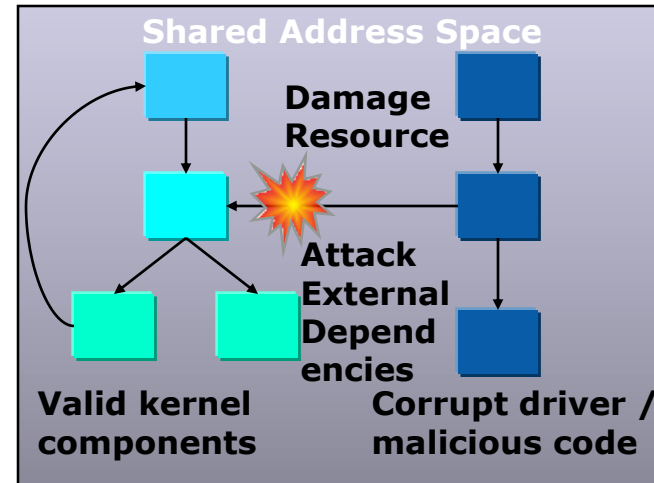
Emerging 'Stack Pivoting' Exploits Bypass Common Security- APSA13-02 exploit:

Generalized Attack Vectors

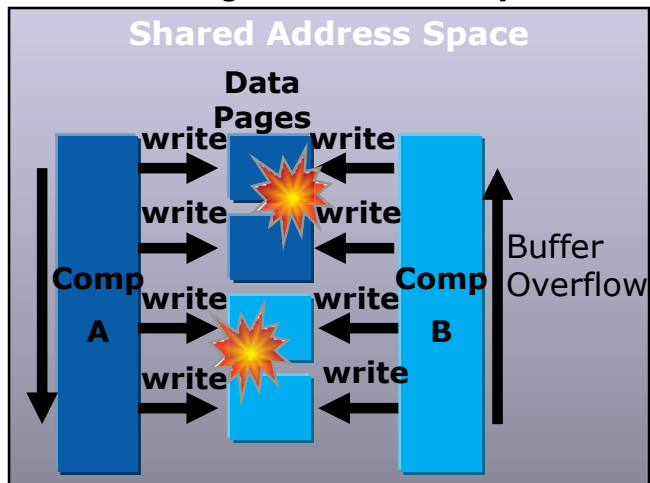
Circumvent



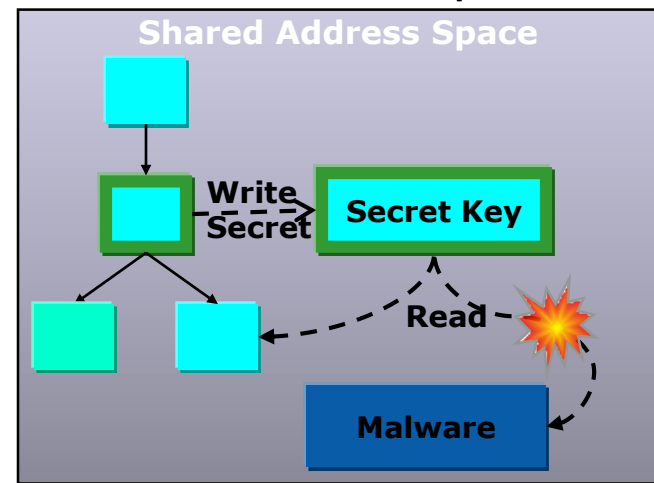
Disable



Inject/Modify

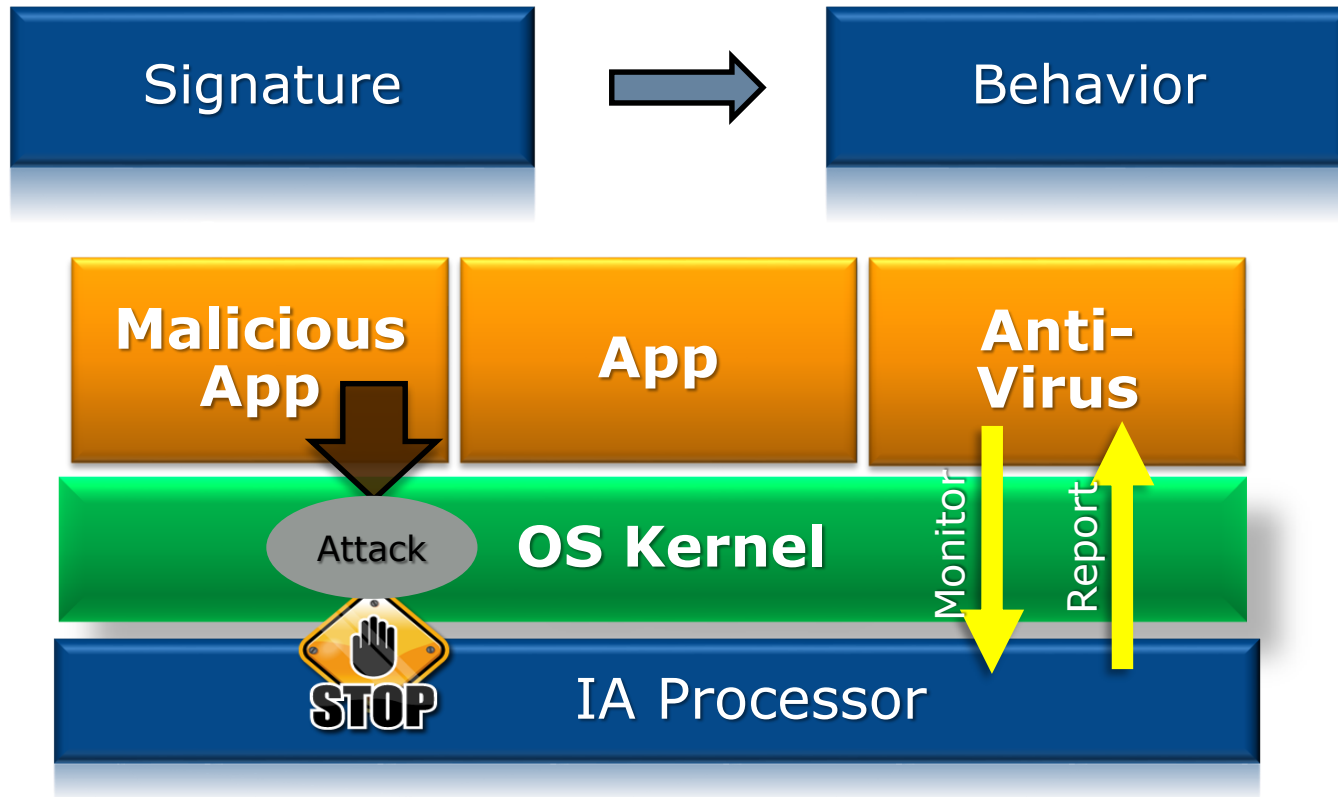


Eavesdrop



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Paradigm Shift



Monitor behavior

Detect onset of the attack

Prevent suspicious access

"Behavior-based" detection to stop zero-day attacks

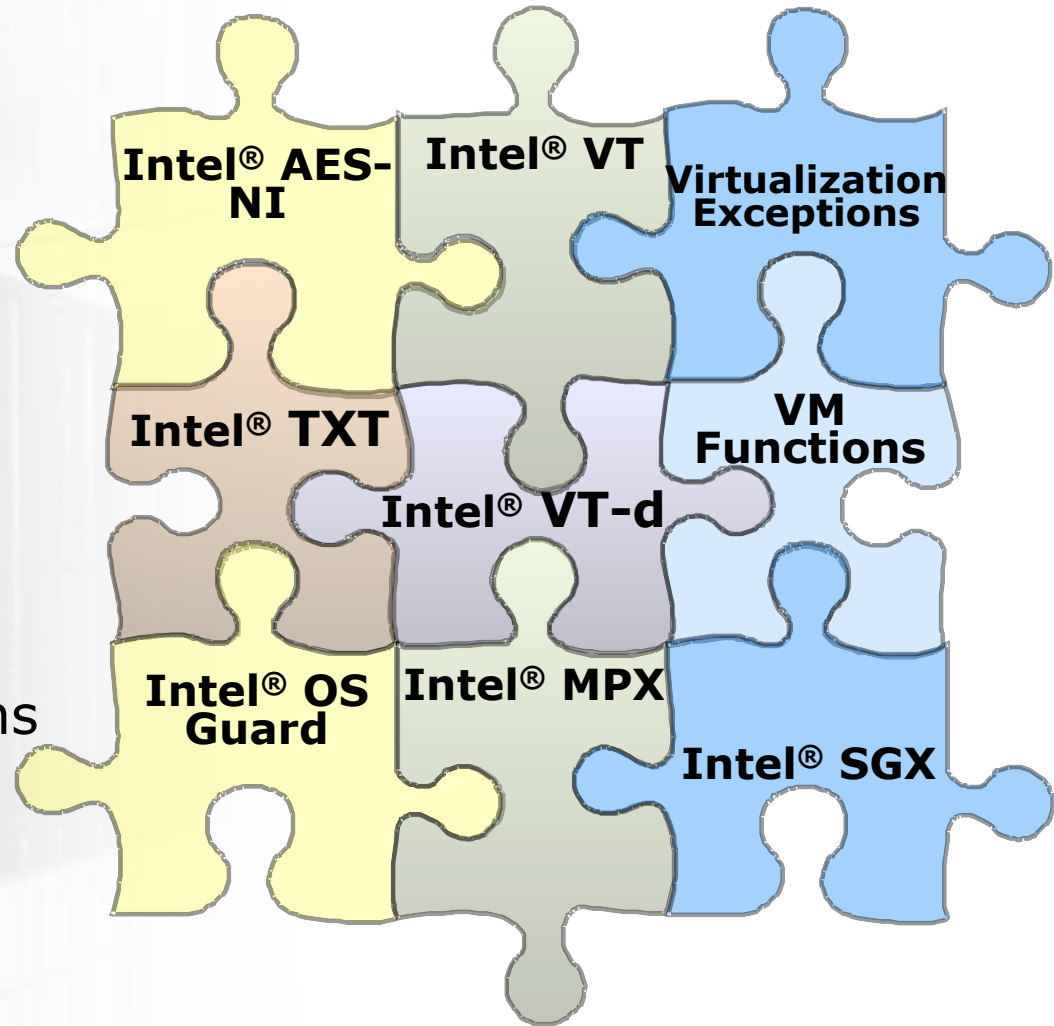
Putting the Defenses Together

- Trusted Launch
- Measurement
- Software Isolation
- Device Isolation
- Crypto Acceleration
- Introspection Acceleration
- Supervisory Execution Prevention

Forward Looking...

- Buffer Overflow Protections
- Minimal TCB

...



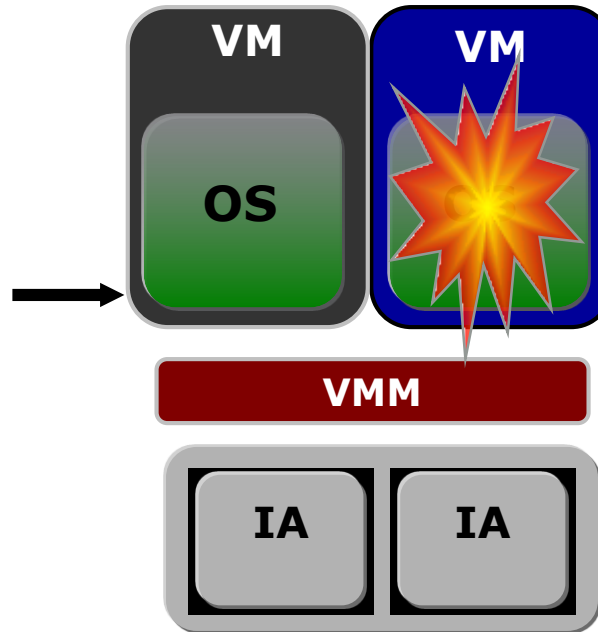
Intel® Trusted Execution Technology (Intel® TXT)
Intel® Virtualization Technology (Intel® VT) for Directed I/O (Intel® VT-d)
Intel® Virtualization Technology (Intel® VT)
Intel® Memory Protection Extensions (Intel® MPX)
Intel® Software Guard Extensions (Intel® SGX)

Evolution of Memory Protections

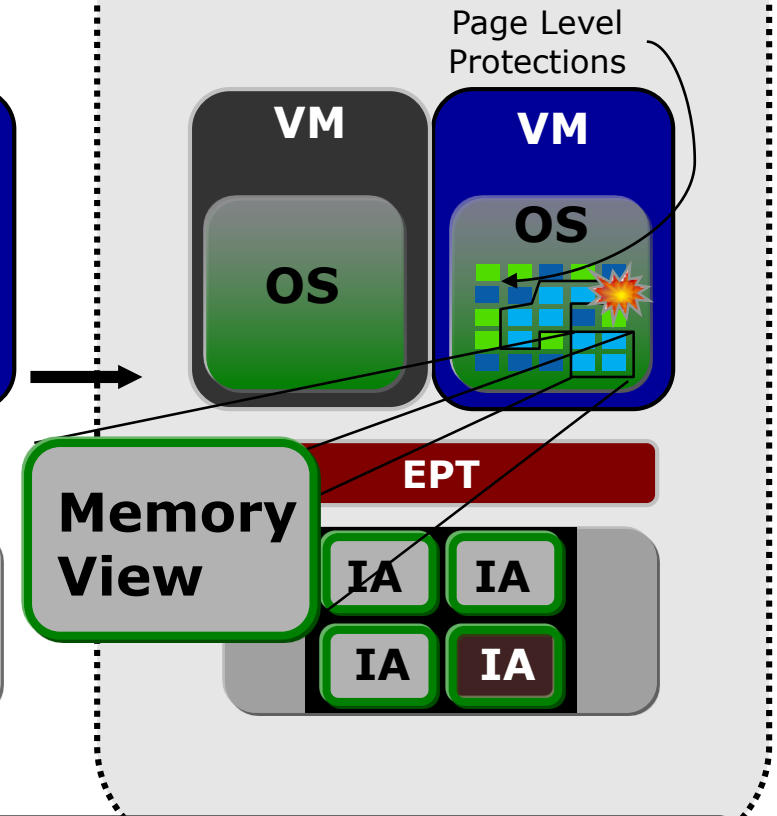
Privilege levels based on protection rings



Multiple virtual machine isolation

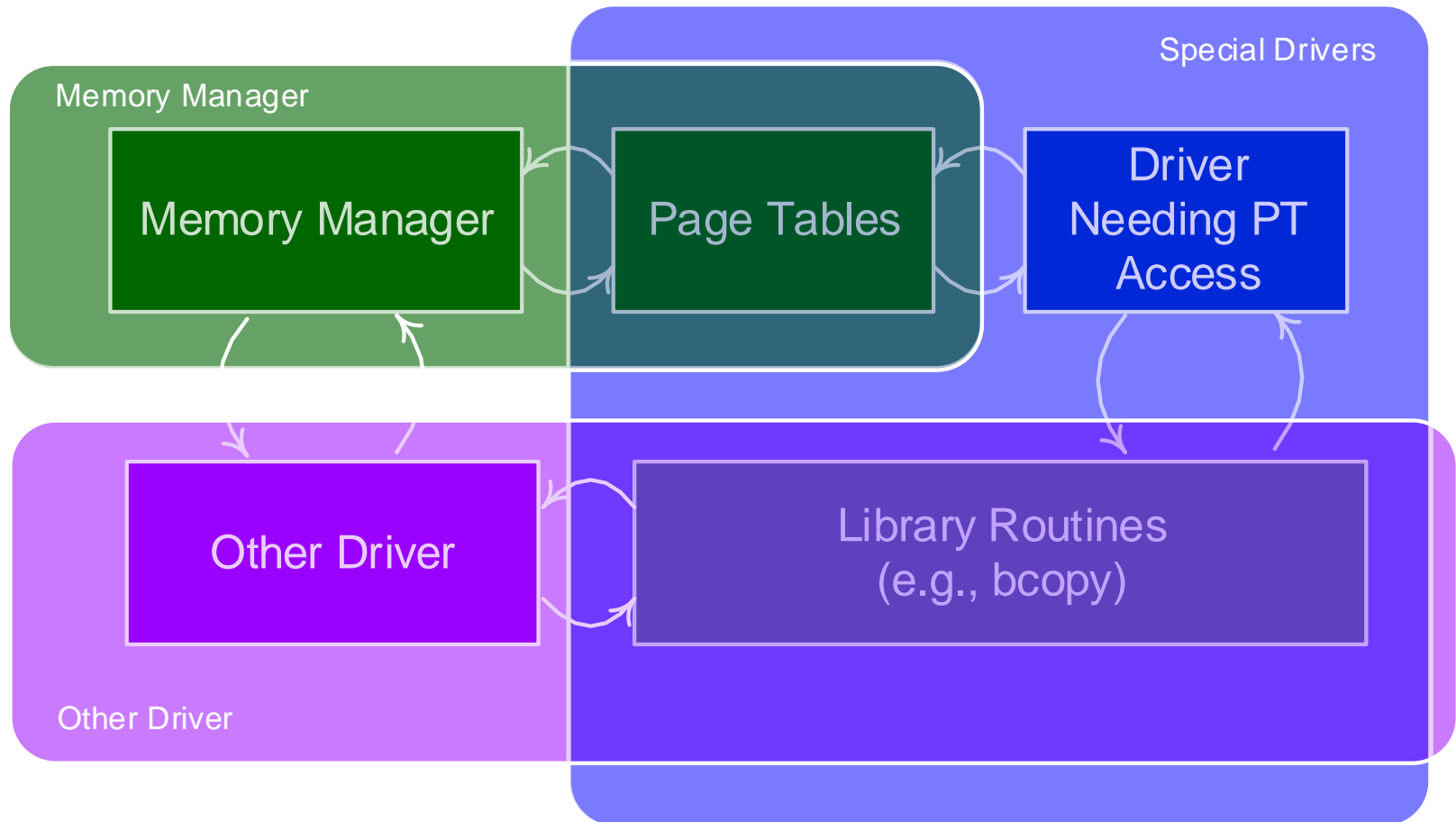


Granular isolation within an address space



Reduce the attack surface while minimizing overhead

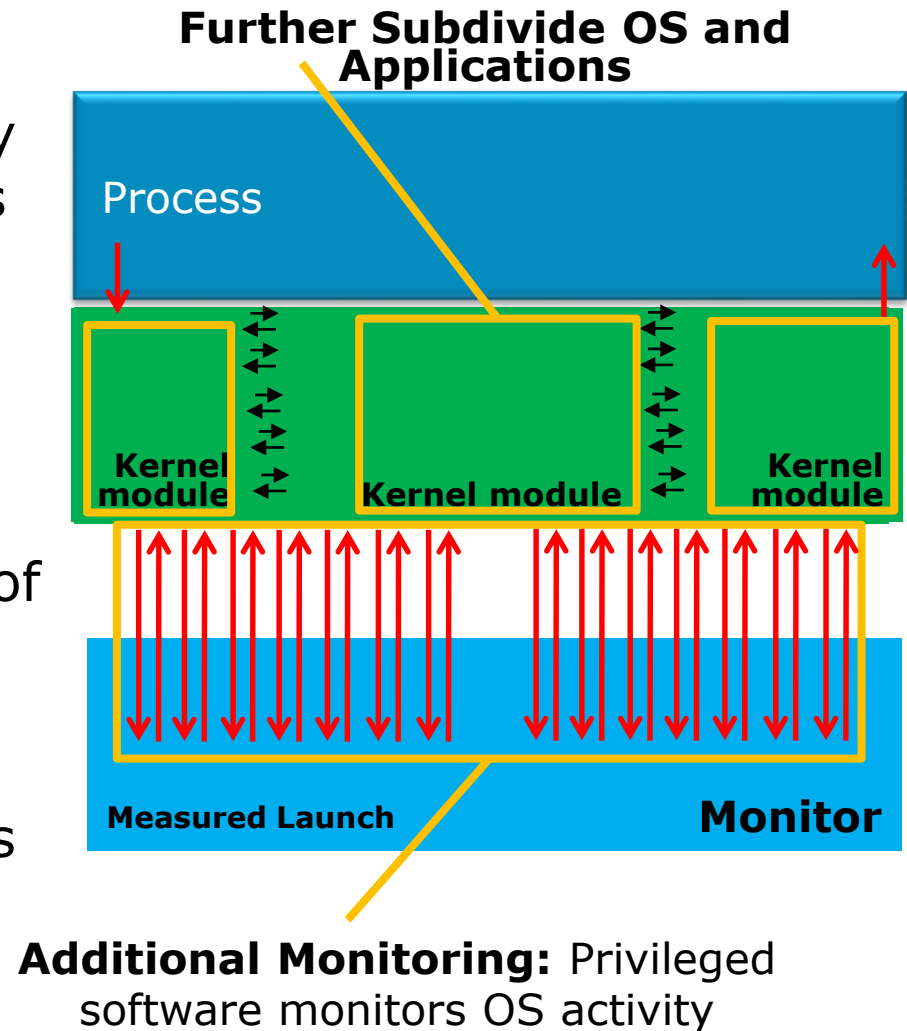
Overlaying Granular Protections



Accommodates existing OS methodology and legacy code

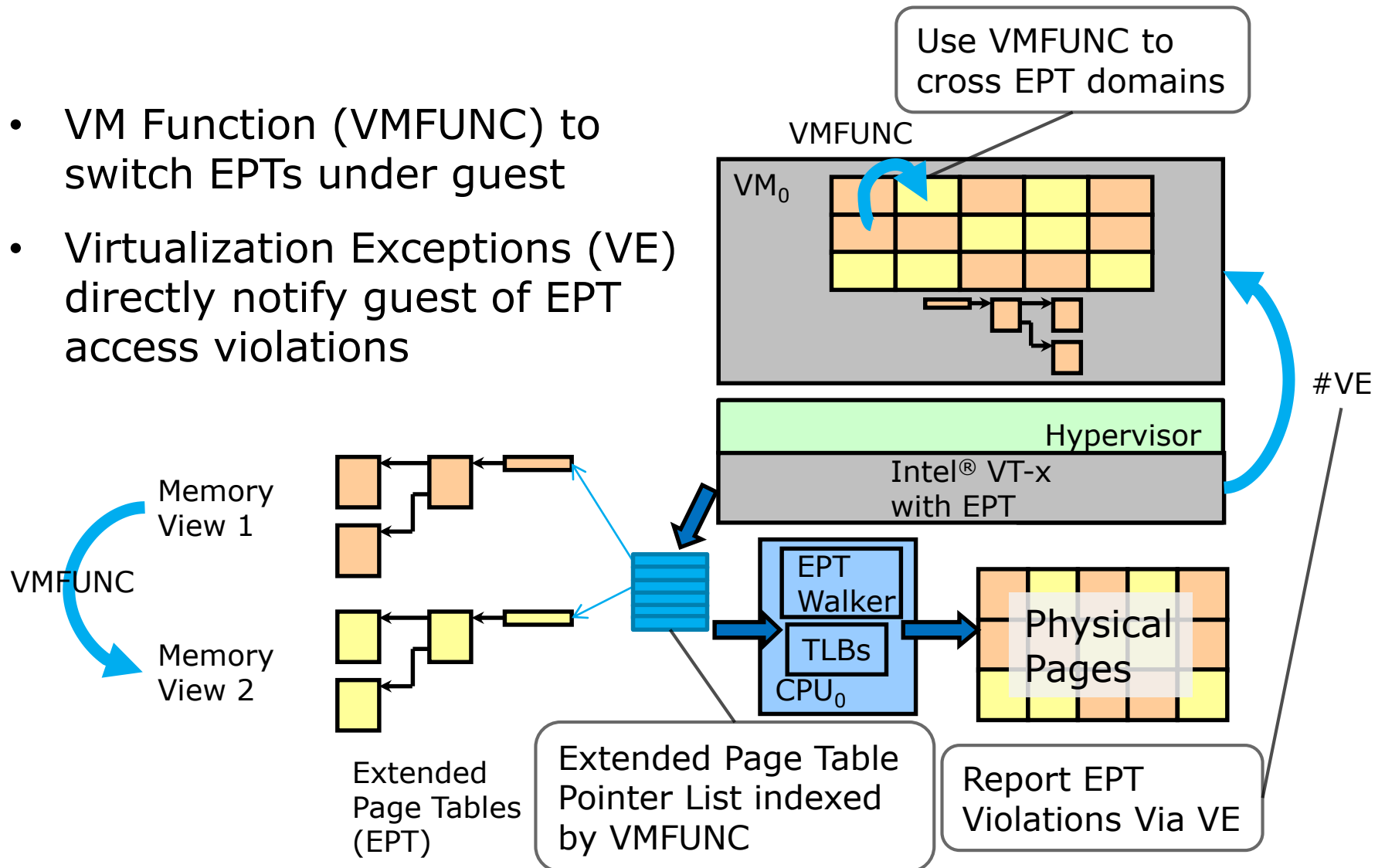
Accelerating Granular Isolation

- Intel® Virtualization Technology (Intel® VT) enables protections beyond the OS
- Overlays additional protections and monitoring policies by enabling memory views
- Provides continuous detection of illicit behaviors
- Accelerated using VM Functions and Virtualization Exceptions...

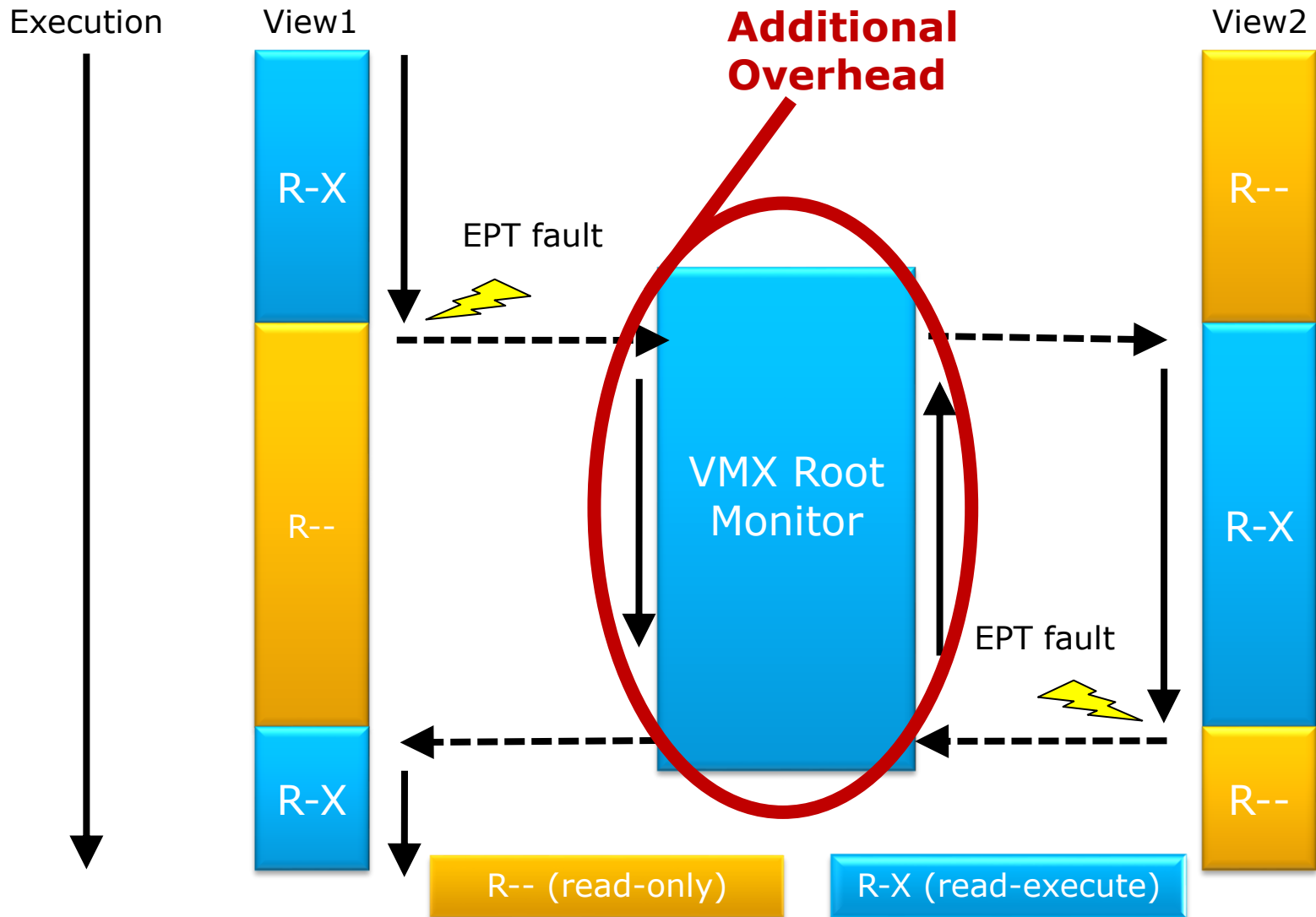


Extended Page Tables for Isolation within VM

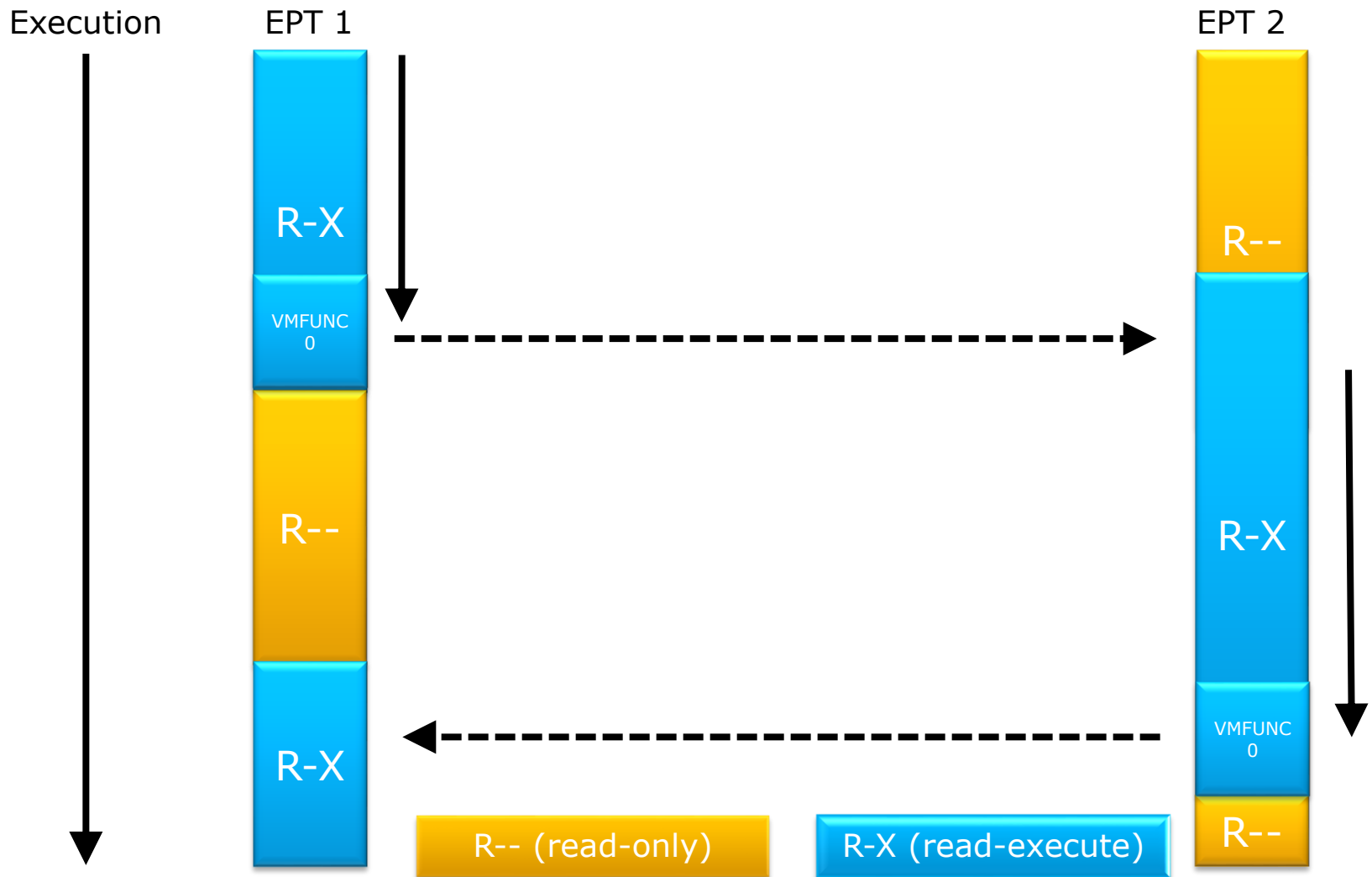
- VM Function (VMFUNC) to switch EPTs under guest
- Virtualization Exceptions (VE) directly notify guest of EPT access violations



Granular Isolation (Before)

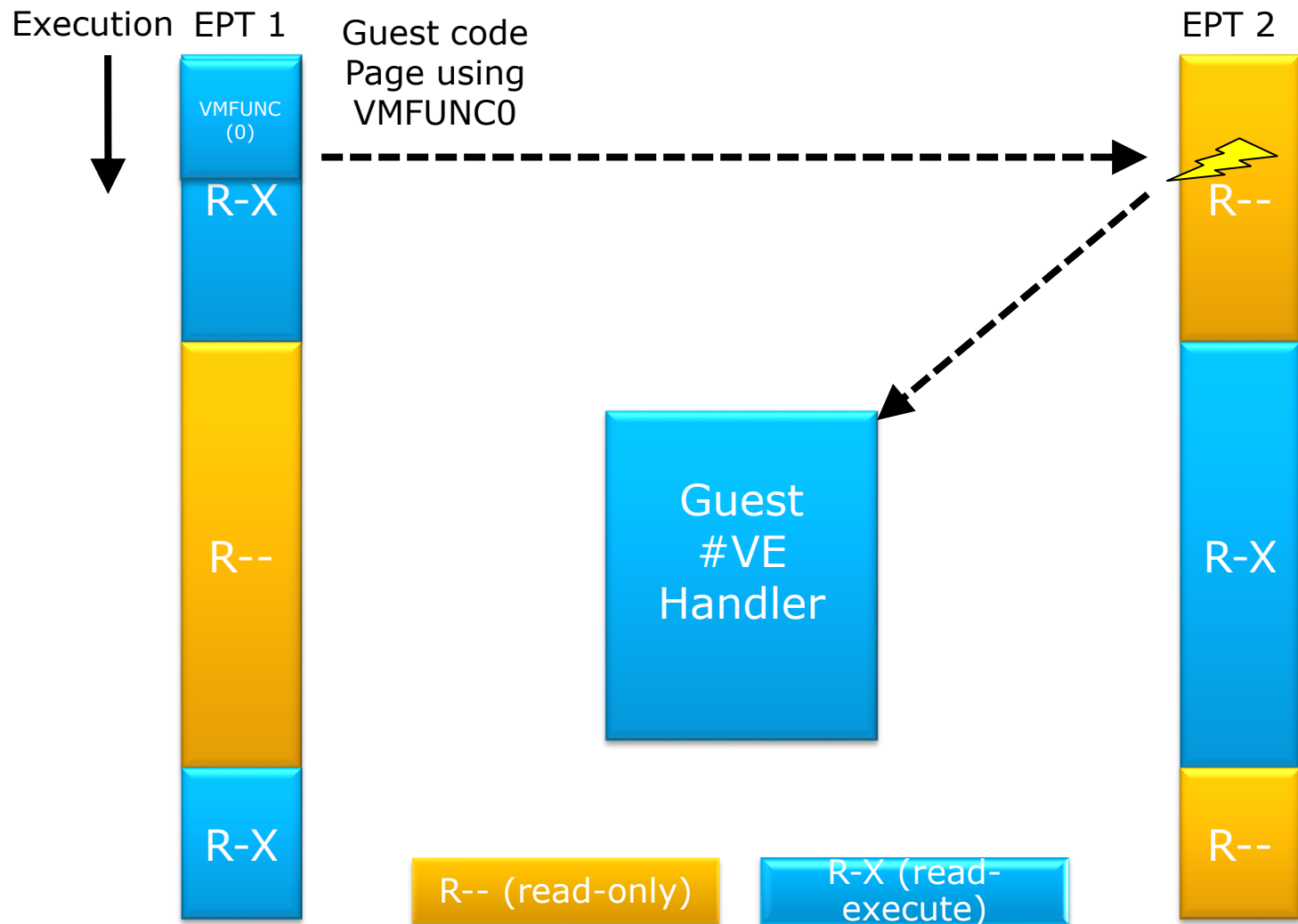


Granular Isolation with VM Functions



Enforce Control Flow Integrity with Intel® VT

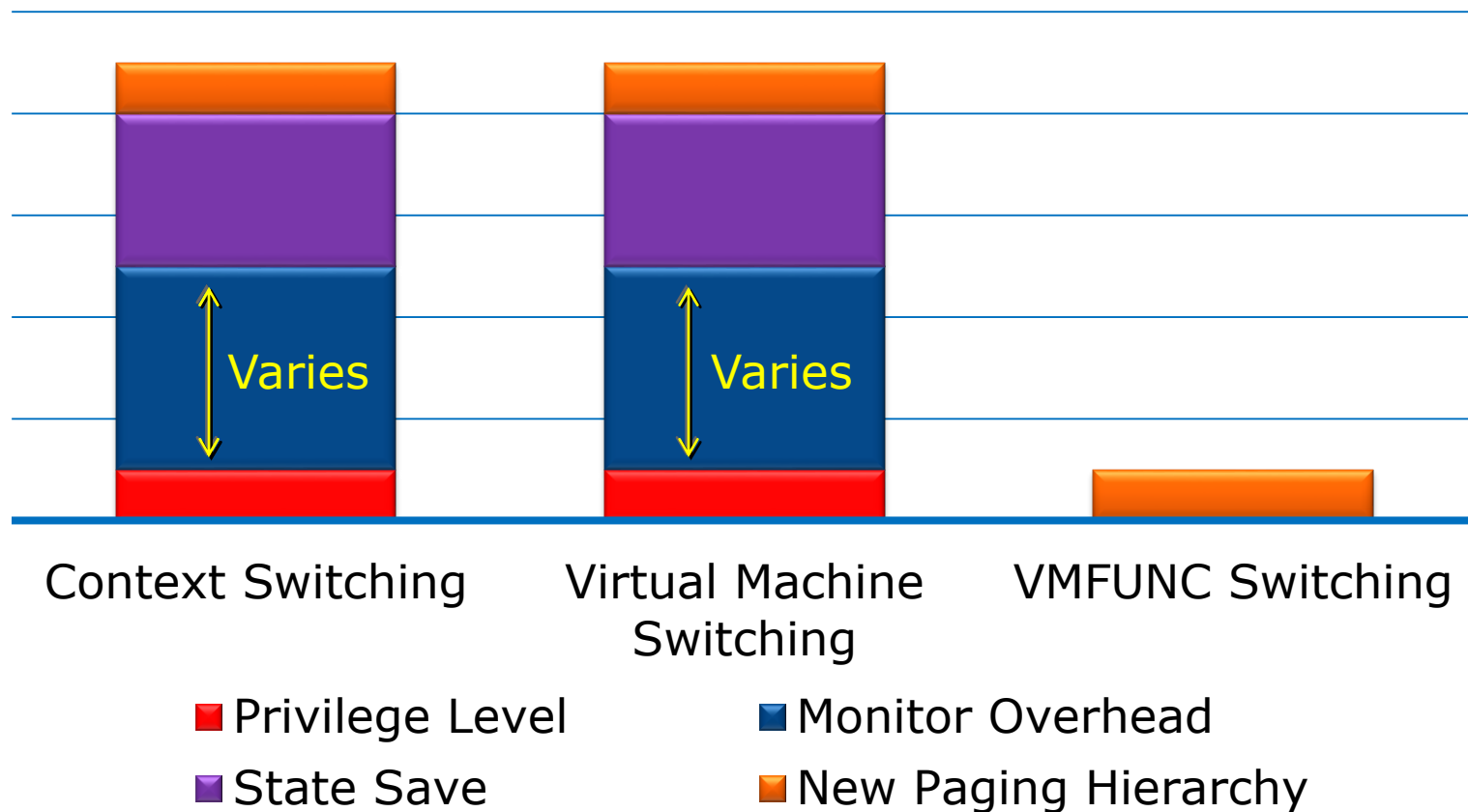
Monitoring with Virtualization Exceptions



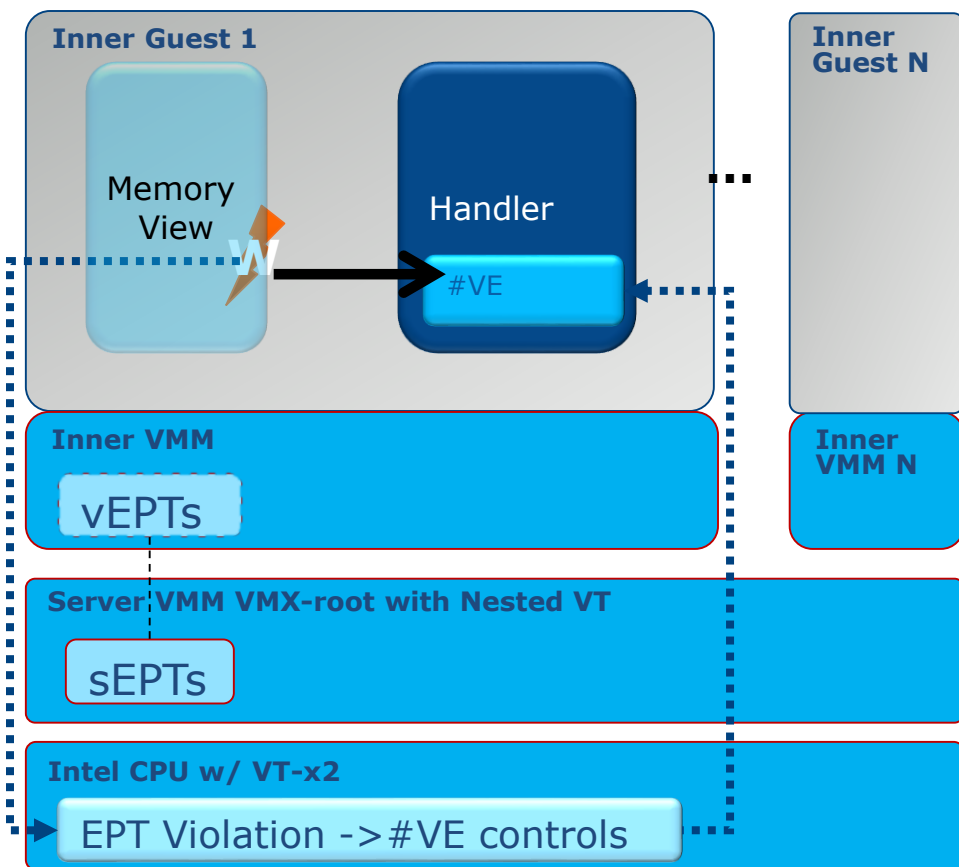
EPT Exceptions directed to the guest

VM Function for Switching

Relative Performance Comparison



Layering Virtualization and Introspection

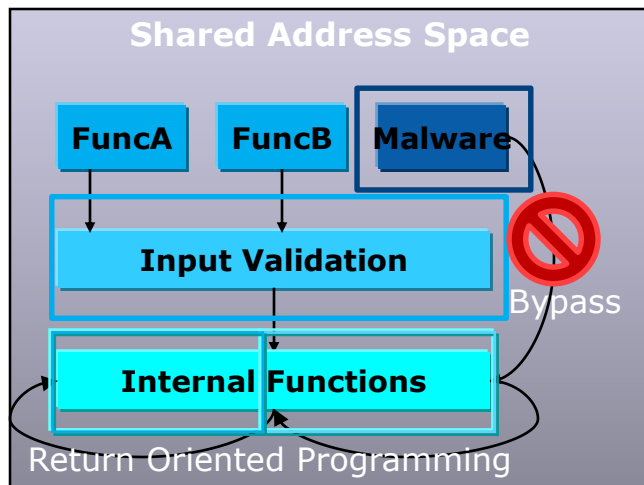


- Root VMM supports VT nesting (with EPT shadowing)
- Root VMM and guest opt-in to enable features
- VMFUNC switches authorized EPTs without engaging VMM(s)
- EPT violations reported via #VE to guest directly
 - No VM Exits for guest policies
 - No additional overhead for VMMs
- Root VMM decides which pages #VE and which will VM Exit
 - Disambiguates copy-on-write and other VMM notification needs

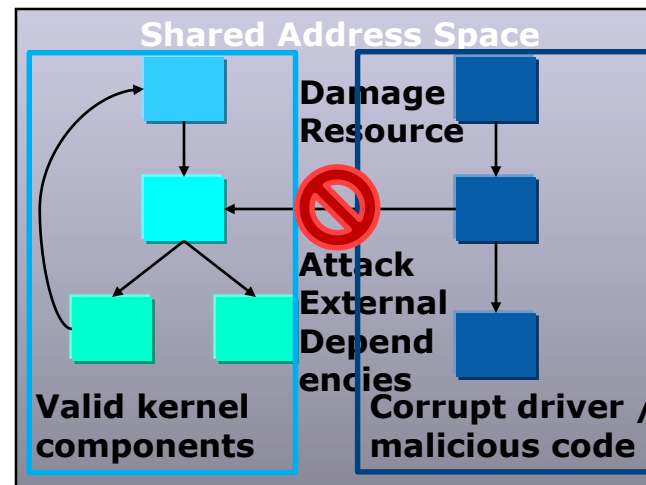
Enables efficient introspection across multiple VMs

Revisiting Attack Vectors

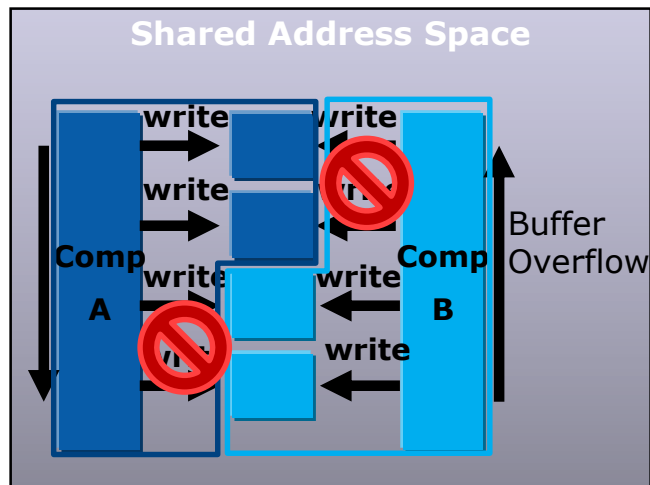
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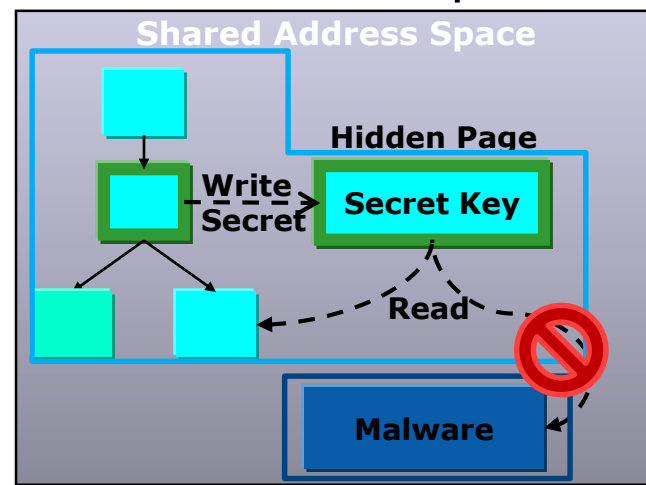
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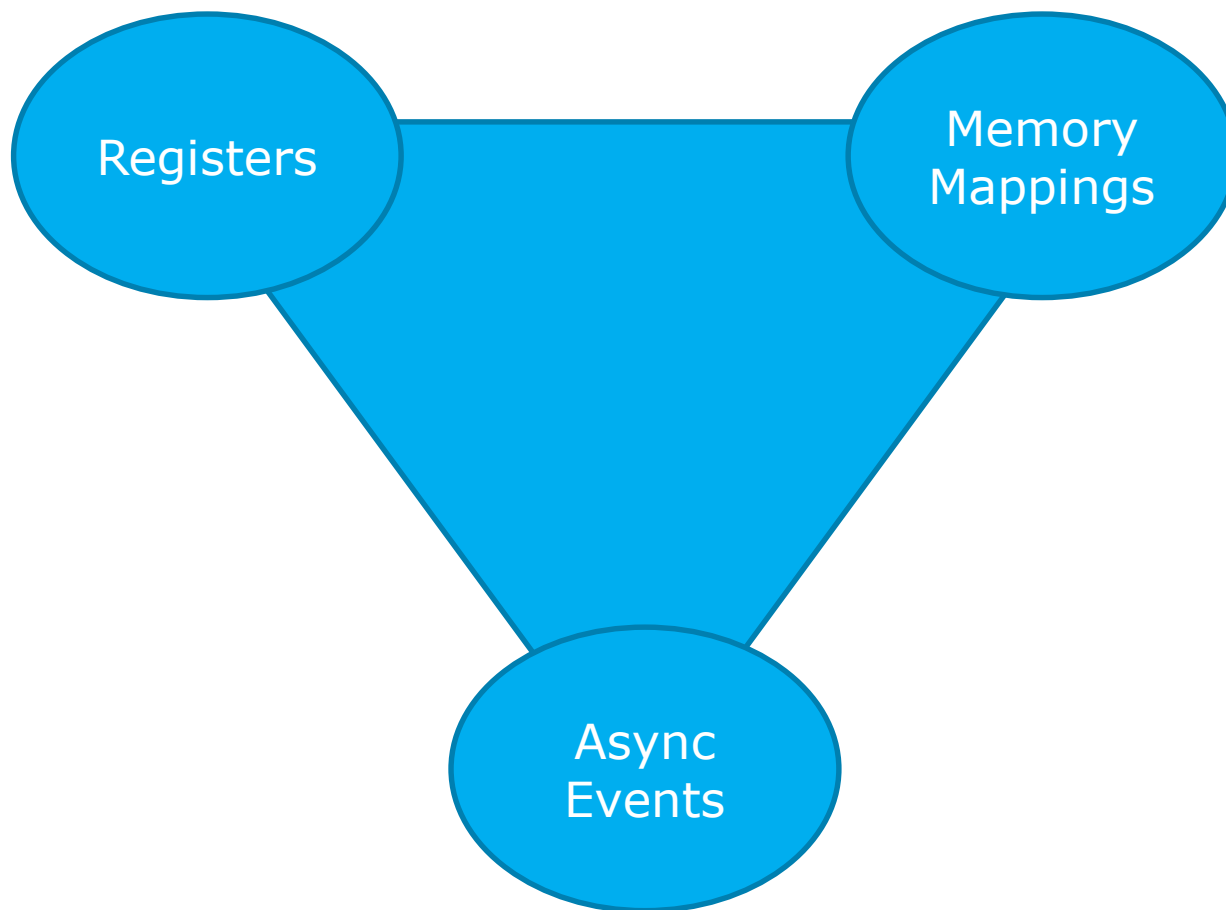
Eavesdrop



Overlay memory views to monitor software behavior

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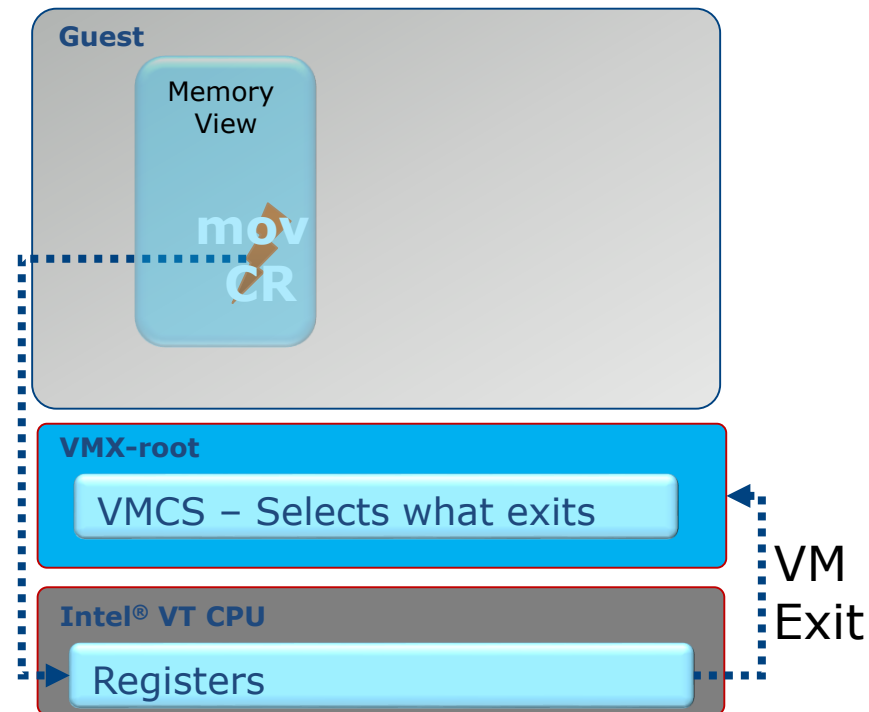
Overlaying Protections: Things to Consider...



May also address external devices depending on usage

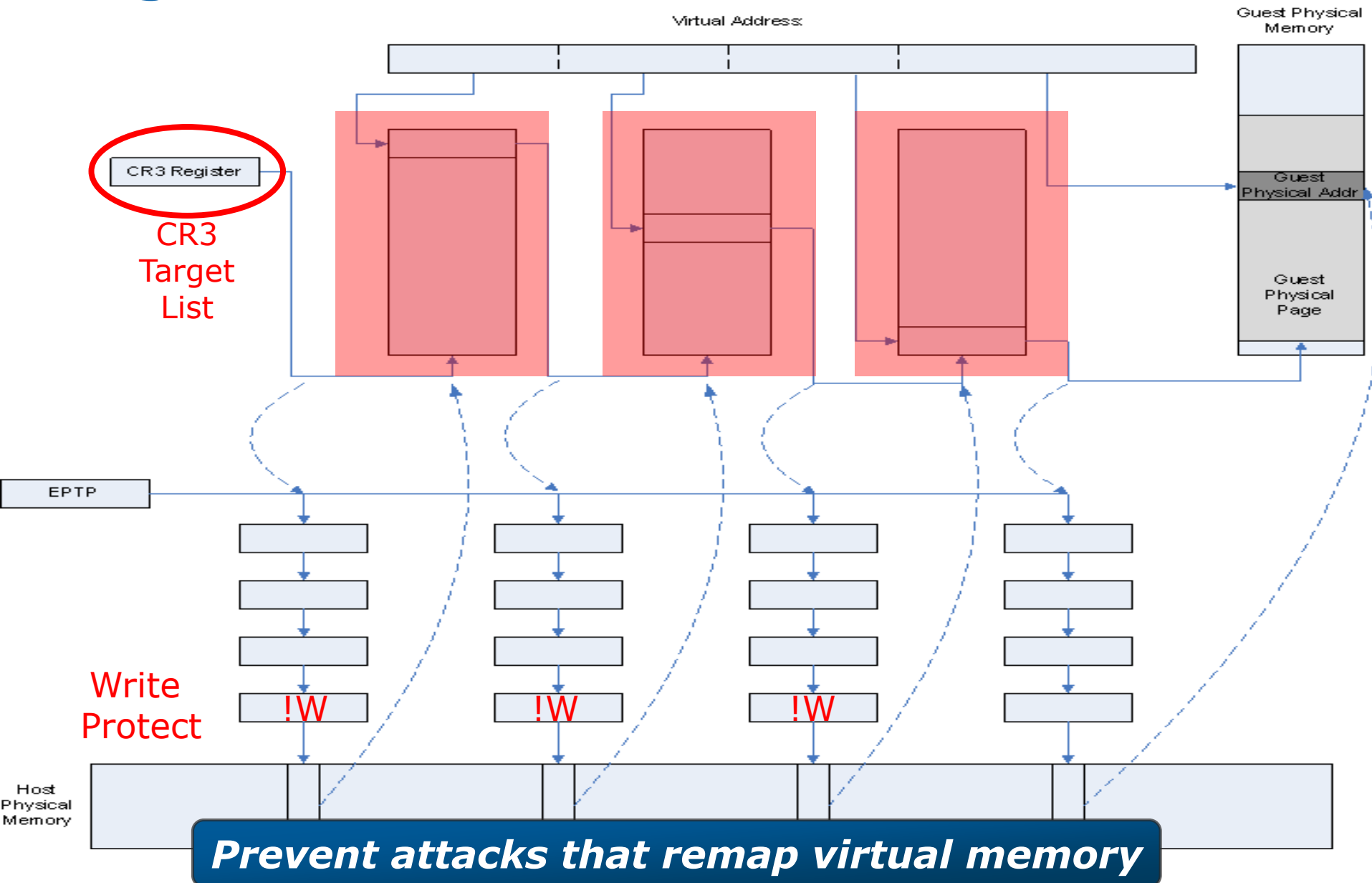
Monitoring Processor Registers

- VMM can be configured to intercept changes to:
 - Model Specific Registers
 - Control Registers
 - Debug Registers
 - Descriptor Tables (IDTR...)
 - Mode dependent...
- VMCS determines what registers to monitor
- GPRs including the stack pointer can be checked at boundaries and on events



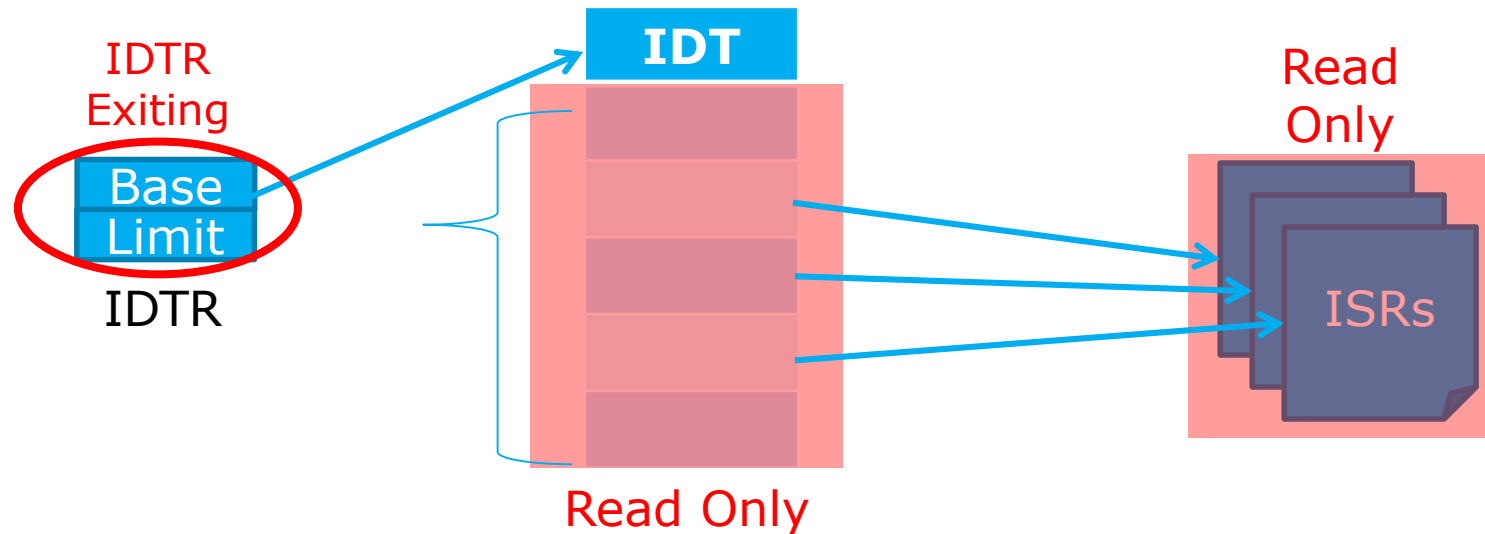
Monitor processor state to prevent attacks

Page Table Edit Control



Interrupts & Asynchronous Events

- Protect Interrupt Descriptor Table & Register
- Trust Interrupt Service Routines or own ISR stub
- Stub code protects state
 - Stack
 - General Purpose Registers

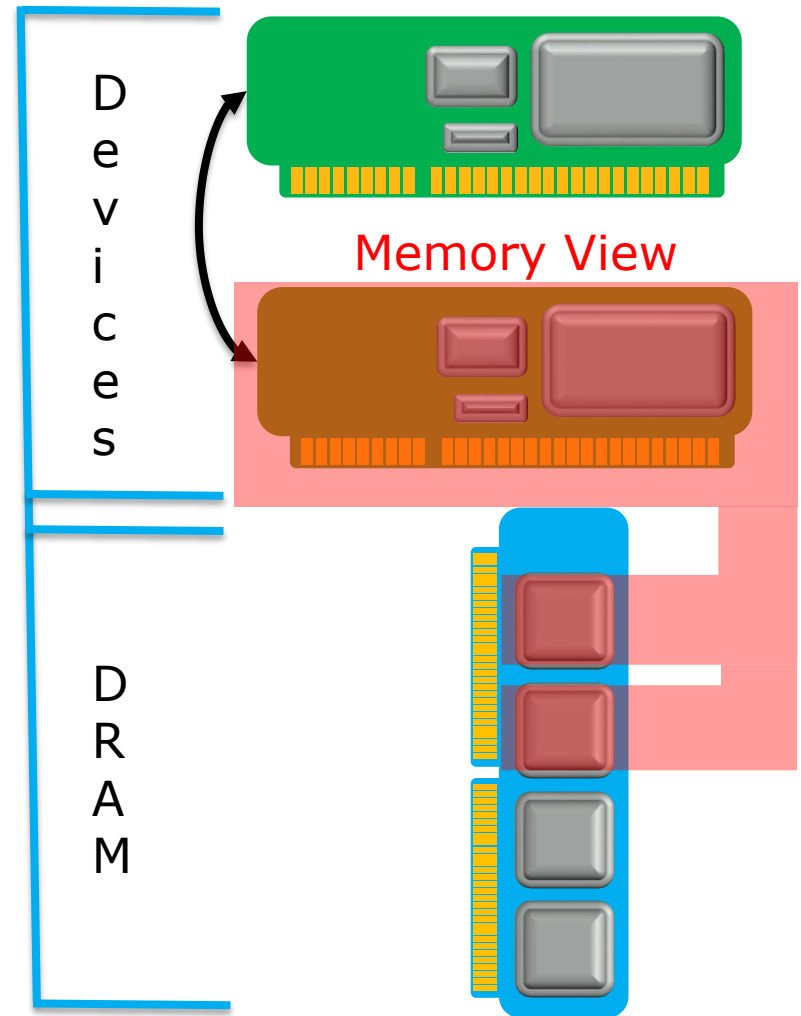


Protect or intercept asynchronous paths

Devices

- Device space configuration
 - Programmed IO in/out
 - Relocation of device registers in memory/BAR change
 - Trigger VM Exit
- Memory Mapped IO
 - Device registers
 - Covered by EPT policy
- DMA
 - Buffers in memory
 - Covered by EPT policy

Address Space



Intel® VT-d protects against compromised devices

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McAfee® Deep Defender Overview



- McAfee® DeepSAFE™ technology in the McAfee® Deep Defender product can safely monitor writes to critical memory assets
- The Deep Defender component within the operating system understands the O/S layout and rootkit techniques
- The DeepSAFE component uses CPU primitives to monitor CPU and memory so that pages containing sensitive code and data are access-controlled

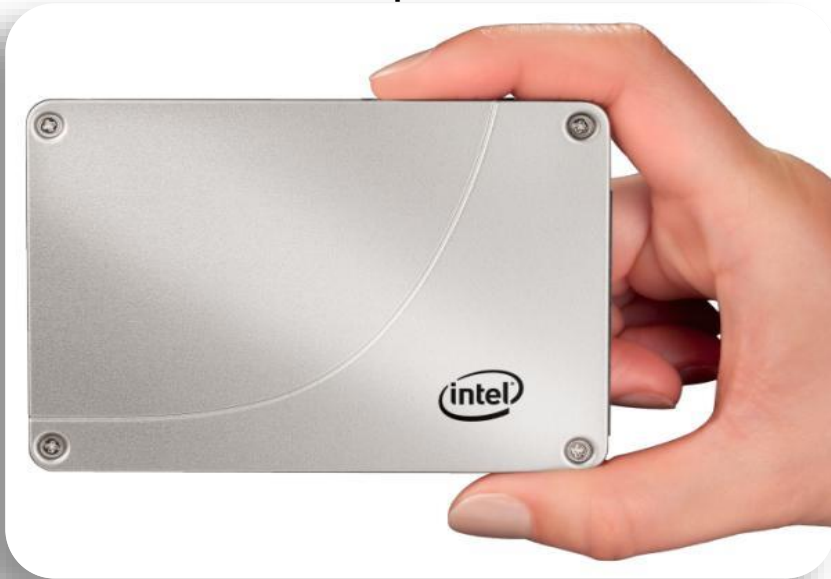
Providing Better Protections



Input



Audio



Storage

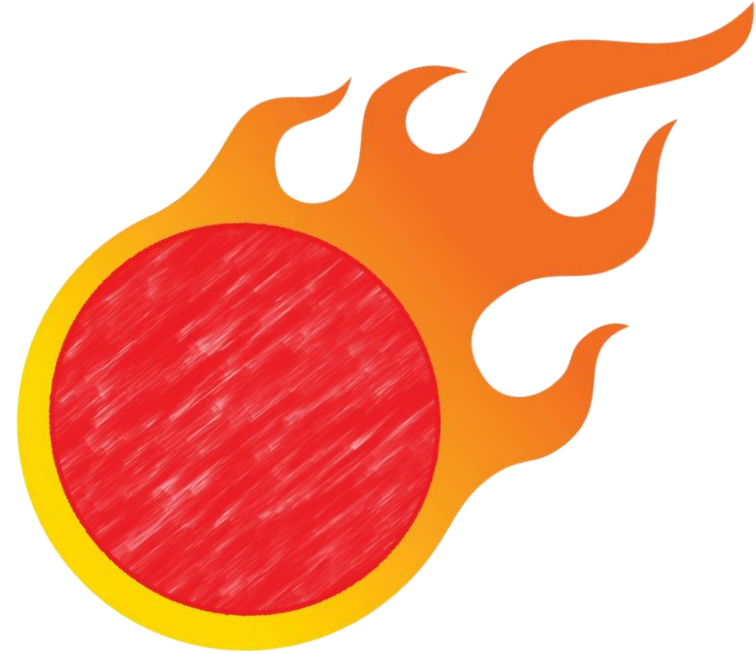
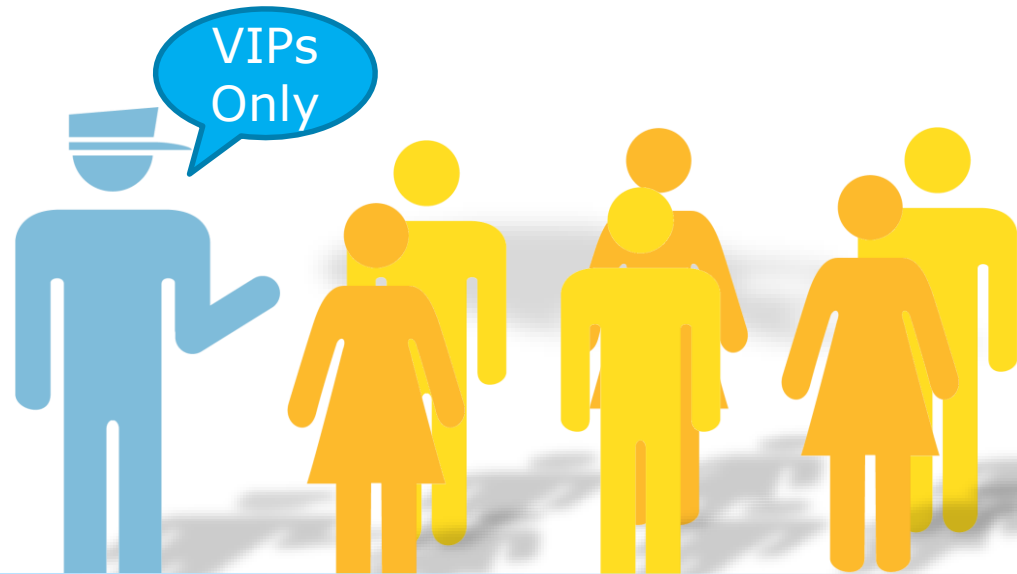


Video
Hot Chips 2014 | Tutorial

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Democratizing Security

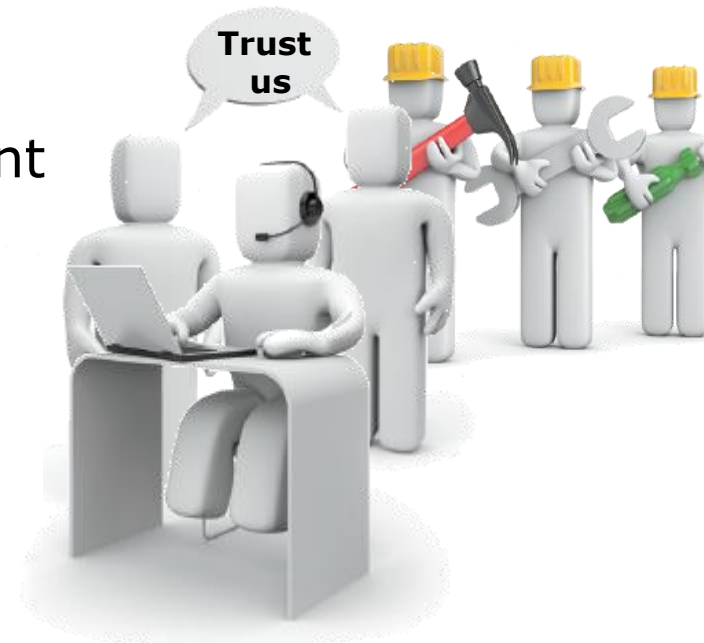
- Software relies on a Trusted Execution Environment (TEE) in case other defenses fail
- Isolated hardware and restricted modes limit use
- A future where there are enough TEEs for all?



Scaling Trusted Execution Environments for the many

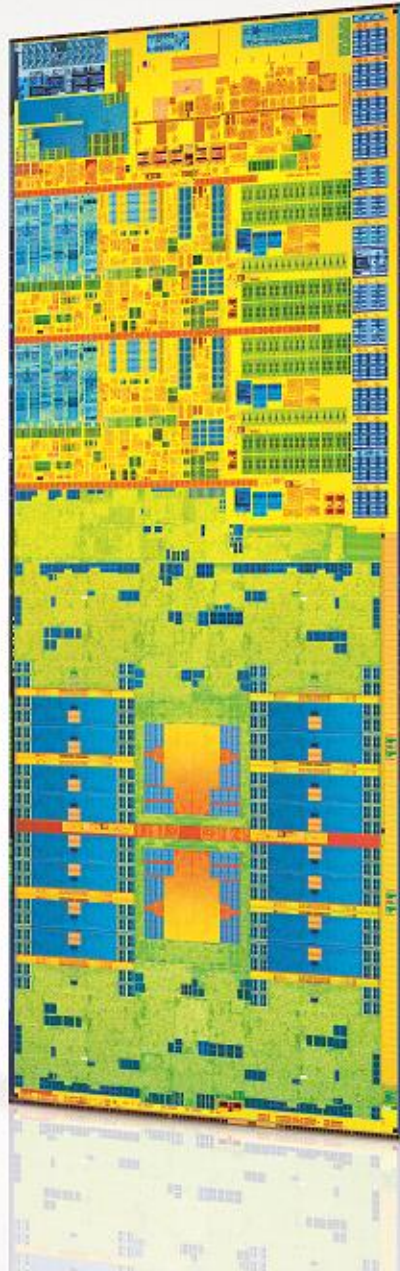
Trust How Many?

- Trusted Computing Base (TCB):
 - Set of all hardware, firmware & software part of a trusted environment
- Minimizing the TCB:
 - Remove Software Stacks
 - Remove Drivers
 - Remove Devices
 - Remove Firmware...



TCB

Trust The Processor

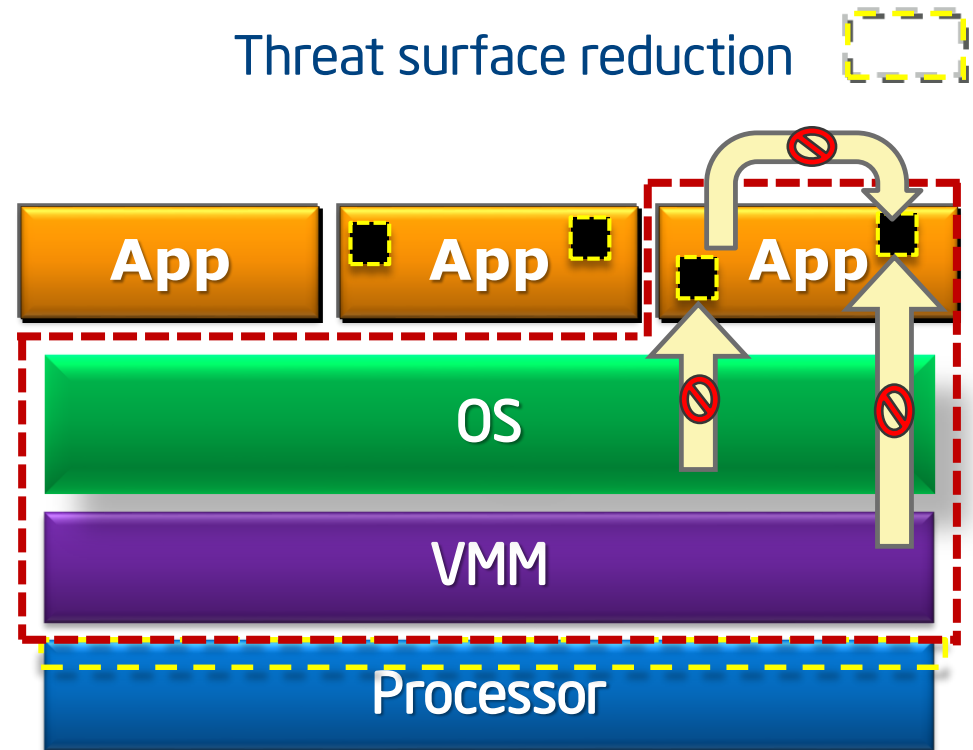


Scaling Trust with a Minimal TCB

Define precise trust boundaries

Remove extraneous components from the trust boundary

Reduce TCB to the processor



Scalable security within mainstream environment

Utilize Existing Instruction Set Security Primitives

E.g. Intel® Advanced Encryption Standard New Instructions:

AESKEYGENASSIST

ShiftRows()
SubBytes()
MixColumns()
AddRoundKey()

AESIMC

InvShiftRows()
InvSubBytes()
AddRoundKey()

AESENC

InvShiftRows()
InvSubBytes()
InvMixColumns()
AddRoundKey()

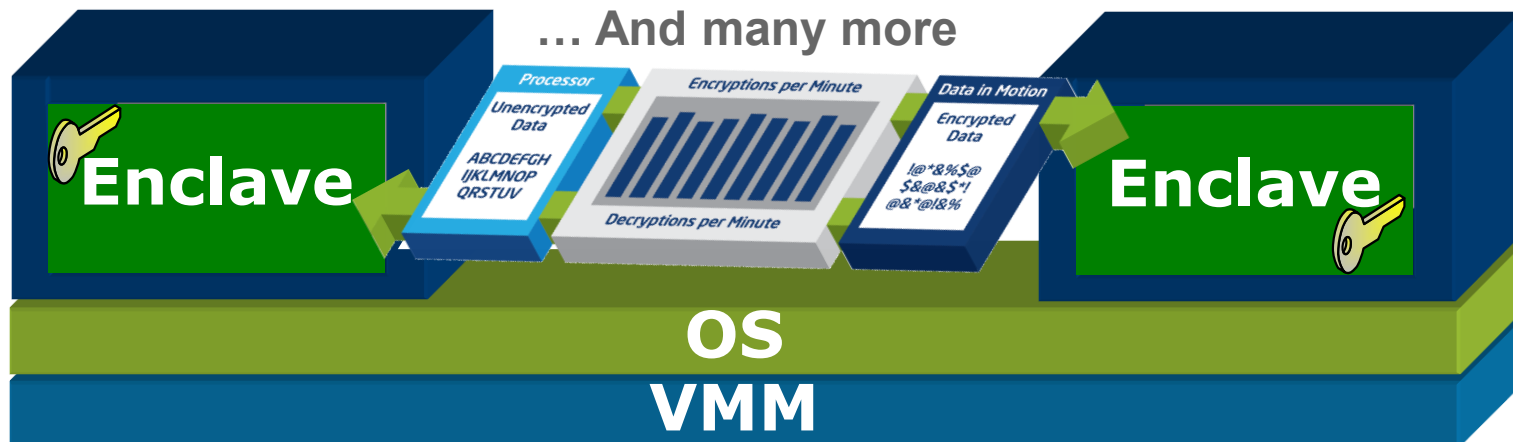
AESENCLAST

ShiftRows()
SubBytes()
AddRoundKey()

AESDEC

AESDECLAST

... And many more



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Summary

- Increasingly sophisticated attacks require better defenses
- Moving from signatures to behavioral models
- Next generation processors deliver new capabilities for advanced software monitoring and protection
- Ability to layer protections over legacy software
- Minimizing the Trusted Computing Base is the next step...

Biography



David Durham is a Senior Principal Engineer and Director in Intel Labs. His research team developed anti-malware and cryptographic security features currently found in hundreds of millions of Intel processors. David also developed policy-based network management technologies, created security solutions shipping in Intel® vPro™ platforms and worked with McAfee to deliver virtualization-based anti-malware products. Collaborating with industry leaders, his team developed IEEE 802.1 security protocols and advanced network access control capabilities now embedded in tens of millions of Intel platforms. He is a prolific author on computer communications, having written a book, multiple publications and several Internet protocol standards deployed in millions of connected devices. David received two Intel Achievement Awards, was granted over 100 US and international patents and earned his B.S. and M.S. degrees in Computer Engineering from Rensselaer Polytechnic Institute.

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